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Hydrogen Peroxide Contents in Some Marine Foods

Shigeru UMEMOTO

Abstract: The H_2O_2 determination using an oxygen elcetrode was modified and a higher recovery of added H_2O_2 was attained by use of acidic extractant (pH 2.7) in place of neutral extractant adopted in the original method. The determinations were made on several kinds of marine foods. The H_2O_2 contents (on dry basis) of food samples processed without any treatment of H_2O_2 were found to be about 0.5 ppm in "Kazunoko" (salted herring roe), several ppm in "Kamaboko" (fish cake) and in "Shirasu" (boiled whitebait), and these seem to be a background level in the marine foods mentioned above. Salted fish roe foods, "Kamaboko" and "Shirasu" on the market showed similar levels of H_2O_2. On dried fish products of many kinds on the market, the H_2O_2 determinations were made after heat treatment, at 99—100 °C for 10 min, because these foods are usually served after broiling. The dried fish products showed higher contents, 4.9 ppm H_2O_2 in mean. Such a higher value seems to originate partly from lipid peroxides in the foods and partly caused by heat treatment of the sample.

In recent years, together with the carcinogenicity of H_2O_2 having been made an issue, the Ministry of Health and Welfare revised part of the Food Sanitation Law, and proclaiming that, "Prior to finishing an end food product, H_2O_2 must be decomposed or eliminated,"[1] the regulation on the use of H_2O_2 in foods was substantially strengthened. To cope with this regulation tightening, the establishment of a method of analysis of trace H_2O_2 in foods was sought. The author[2] reported earlier on a modified colorimetric method in which improve-

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ments to enhance sensitivity were made to the H_2O_2 colorimetric method of MIYAMOTO et al.[3] UTSUKI et al.* developed a H_2O_2 measuring device equipped with a diaphragm-type oxygen electrode, while TOYODA et al.[4-6] reported on a method of analysis of trace H_2O_2 in foods using this device.

After regulation tightening on the use of H_2O_2, H_2O_2 treatment was approved for the manufacturing process of salted "Kazunoko" (herring roe) alone, but it is required that it be verified that there is no H_2O_2 remaining in the product by an oxygen electrode-type of H_2O_2 measuring device. The oxygen electrode method is a notch higher in sensitivity than the aforementioned modified colorimetric method, and with respect to solutions can measure H_2O_2 to a level of 1/100 ppm. Upon measuring the H_2O_2 in "Kazunoko," fish paste products and "Surimi" (minced fish meat) by the measurement method of TOYODA et al. (hereafter shortened to original method), it seemed as if the samples that were not subjected to heat treatment often gave values on the low side, so that improvements were made to part of the original method. By means of this modified method the H_2O_2 in salted seafoods and dried products was measured, and even food products untreated with H_2O_2 revealed H_2O_2 , albeit a trace, yielding results that were not necessarily ND. In the following pages, a report is made on a partial improvement of the H_2O_2 measurement method of TOYODA et al. which uses an oxygen electrode, as well as on the results of analysis of the H_2O_2 in seafoods by that modified method and their background levels.

Experimental method (6)

The reagents used were special grade ones, the albumins used were Miles Co.'s bovine serum albumin Fr. V and chicken egg albumin (recombined five times), and the methyl linoleate used was Sigma Co.-made.

The measurement of H_2O_2 was generally done by the method of TOYODA et al.[4,5]

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* UTSUKI, Yoshio, and Minoru OHASHI: Presentation at the 42nd Fall Convention of the Chemical Society of Japan (Sendai) (1980).

However, instead of adopting the extraction treatment of samples by a neutral buffer solution as in the original method, for the reason described later an acidic buffer solution (pH 2.7) was used to extract the samples. Using an Oritector Model III H_2O_2 measuring device (made by Oriental Electric Co. Ltd.) equipped with a diaphragm-type oxygen electrode and putting the sample extract into the cell of this device, catalase was added at the point where the pH was adjusted (6.2). The rise in the dissolved O_2 concentration associated with the decomposition of H_2O_2 in the sample extract and the formation of O_2 was detected and recorded with the oxygen electrode, and the H_2O_2 concentration was determined. The concentration of the standard solution of H_2O_2 for calibration curve purposes was determined by iodometry, while the quantification of proteins was done by the microburette method.[7)]

As samples, fish roe products such as "Kazunoko" and "Sujiko" (salmon roe), fish paste products, "Shirasu" (boiled whitebait), dried fish and shellfish products, fish meal and such were used, with items on the market as well as products and trial products confirmed to be untreated with H_2O_2 being taken up.

Results and discussion

Examination of H_2O_2 measurement method which uses oxygen electrode

With the measurements by the original method of TOYODA et al.,[4,5)] the author* has experienced the fact that whereas fish paste products indicated 0.1 - 0.7 ppm in terms of H_2O_2, with unheated raw "Surimi" either H_2O_2 is not detected or an extremely low value is indicated. When based on the original method, with sample "Kazunoko" and frozen "Surimi" the added H_2O_2 recovery rate would indicate extremely low values under 20% in many cases. Whereas TOYODA et al.[4)] have stated that high recovery rates of 87 - 99% were obtained by the original method, the author only got low recovery rates.

(8)

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* UMEMOTO, Shigeru: Summary of presentations at the 1983 Spring Convention of the Fisheries Society of Japan, p. 212 (1983).

As the cause of the recovery rate being low in the analysis of H_2O_2, apart from the fact that H_2O_2 itself is unstable and prone to easily decompose, in the extracts of unheated animal and plant tissue samples the action of H_2O_2 decomposing enzymes originating in the raw samples can also be considered. In fact, when H_2O_2 was added to "Kazunoko" extract, as can be seen in Fig. 1 the formation of O_2 was clearly discerned. When the sample extract was heated to boiling or when NaN_3 [8,9] which manifests an inhibitory effect on catalase was added to the extract (0.1 mM in final concentration), in either case the formation of O_2 due to H_2O_2 addition was extremely low. These results indicate that when the samples are raw their extracts possess catalase action, which is thought to be a big factor in lowering the added H_2O_2 recovery rate.

In order to raise the recovery rate, there is a need to avoid to the utmost letting any catalase that might be contained in the sample act during the crushing and extraction treatment of the sample tissue. When the relationship

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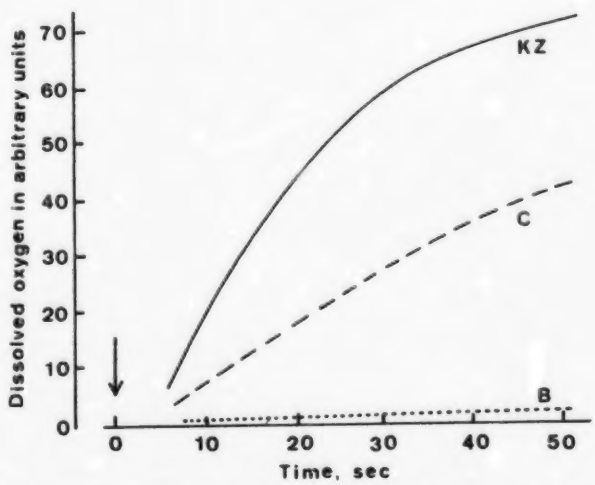

Fig. 1. Changes in dissolved oxygen concentration of "Kazunoko" extracts and catalase solution on addition of hydrogen peroxide.
"Kazunoko" (2 g) was extracted with phosphate buffer solution (0.1 M, pH 7.0) and made up to 20 m*l*. To 2.1 m*l* of the extracts in the cell 20 μl of H_2O_2 (0.2 M) was injected at the time indicated by the arrow.
KZ: "Kazunoko" extracts + H_2O_2
C : catalase solution + H_2O_2
B : blank (phosphate buffer solution + H_2O_2)

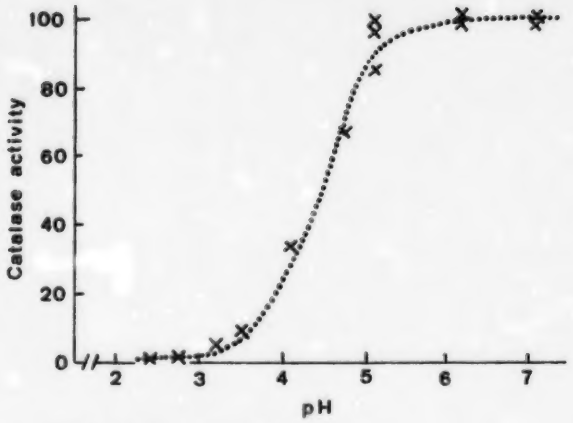

Fig. 2. Catalase activity at pH 2—7.
Activity at pH 7 was defined to be 100.

Reagents

A solution: McIlvaine's buffer solution, pH 2.7, for extraction, keep cool

0.1 M citric acid-0.5 % $KBrO_3$ solution	18.5 vol
0.3 M Na_2HPO_4-0.5 % $KBrO_3$ solution	1.5 vol

B solution: for pH adjustment of the assay solution

0.3M Na_2HPO_4-0.5 % $KBrO_3$ solution

To drive out dissolved oxygen, the A and B solutions were bubbled with nitrogen.

antifoam silicone (Toshiba silicone TS # 737 was used)

Extraction procedure*1

SAMPLE 2 g

(if necessary, steam the sample for 10 min*2)

put in a mortar

+ A solution ca. 5 ml

crush the sample

transfer the sample slurry into a graduated cylinder

+ antifoam silicone, one drop

make up to 20.0 ml by adding A solution

centrifuge, 6,000 rpm, 20 min

Sup

SAMPLE EXTRACTS

*1 Extraction is carried out at low temperature below 10 °C.

*2 Sample is raw and served after cooking, heat treatment before extraction is recommended.

Fig. 3. Reagents and extraction procedures for hydrogen peroxide determination by the modified method.

between the catalase activity and pH was looked at, as shown in Fig. 2 it was seen that above pH 5 the activity is high but below pH 3 the activity becomes extremely low. As a means of improving the H_2O_2 recovery rate, an investigation was undertaken on doing the extraction of the sample under a low pH such as to enable the catalase action to be held down extremely low, and adjusting it to neutral at H_2O_2 measurement time. As a result of various preliminary investigations, it was decided to use for the extractant a pH 2.7 solution of McILVAINE's citric acid - disodium hydrogen phosphate buffer solution which has a buffering capability over a wide range from low pH to the neutral zone, and a modified H_2O_2 measurement method described below was established.

Proceeding as shown in Fig. 3, the weighed sample is extracted with McILVAINE's buffer solution (solution A) of pH 2.7. The extraction process and preservation of the extract are done at low temperature, and the measurement of H_2O_2 is done on the day of extraction. With unheated raw samples which would be cooked to be served for eating (such as dried fish products), it is desirable to carry out the above extraction after heat-treating* the weighed sample for ten minutes at 99 - 100° C.

With respect to the sample extract, H_2O_2 is measured by proceeding as shown in Fig. 4. Putting 1.00 mL** of the sample extract into the cell (kept warm at 30° C) of the H_2O_2 measuring device equipped with a diaphragm-type oxygen electrode, for pH adjustment purposes an equivalent 1.00 mL of solution B is added (making the pH 6.2), and adding a very small amount of antifoam silicone, the cell is sealed. N_2 gas is bubbled into the cell to drive out the dissolved O_2 in the test solution and stabilize the electrode output, at which point 20 μL of catalase solution (5,000 U/mL) subjected to N_2 gas exchange beforehand are injected into

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* The sample is weighed into a small-sized beaker, put into a steamer and heat-treated with steam.

** When the H_2O_2 concentration in the sample extract is high, a small amount is taken and solution A is added to make it 1.00 mL.

pipet 1.00 m*l* of sample extracts into the cell equipped with the oxygen electrode*1
+ B solution 1.00 m*l* (this will make pH 6.2 in the assay solution)
+ antifoam silicone, a very small amount
seal the cell
stabilize the output of the electrode by N_2 gas bubbling*2
inject catalase solution, 20 μl (5,000 U/m*l*)
record the increase of dissolved oxygen concentration on a chart
read the peak heights and calculate the H_2O_2 concentration

*1: Oritector Model III (Oriental Electric Co. Ltd.) was used.
*2: The assay solution in the cell was bubbled with nitrogen.

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Fig. 4. Procedures of hydrogen peroxide determination by the modified method (see also Fig. 3).

the cell. The rise in dissolved O_2 concentration associated with the decomposition of H_2O_2 in the sample extract is detected with the oxygen electrode, and the peak height on the recording chart is read off. From the calibration curve produced using a standard solution of H_2O_2 and the peak height obtained with the sample extract, the H_2O_2 content of the sample is computed. After the measurement a small amount of 0.1 mM NaN_3 solution is put into the cell to wash the inner wall, after which it is thoroughly washed with water. This is to avoid as much as possible the action of catalase from a preceding measurement being carried over to the next reaction solution. (9)

The above gives an outline of the measurement procedure by the modified method. The main points of change to the original method are that the sample is extracted using an extractant of low pH, with the pH being adjusted at measurement time, and that a NaN_3 solution is used for cleansing the cell. With solution A of the extractant, the extract often becomes turbid, and also no deproteinizing effect can be counted on, but in either event there is no particular hindrance to the measurement of H_2O_2.

An example of a calibration curve has been shown in Fig. 5. The practical measurement range by the modified method is 0.01 - 0.1 ppm H_2O_2 (for solutions),

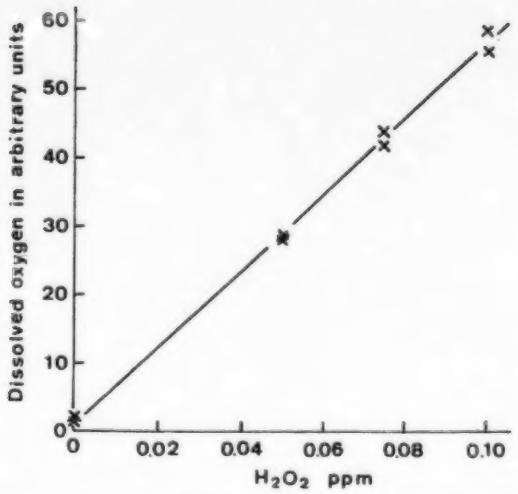

Fig. 5. An example of calibration curve on hydrogen peroxide determination by the modified method (see also Figs. 3 and 4).

Ordinate: Dissolved oxygen concentration on a recording chart in arbitrary units.

Abscissa: H_2O_2 ppm in the assay solution consited of sample extracts 1 m*l* and B solution 1 m*l*.

Table 1. Recovery of hydrogen peroxide determined by the modified method.

Sample and treatment	Recovery of H_2O_2
"Kazunoko" (salted herring roe)	74.8 %
〃	83.9
"Frozen Surimi" (minced meat from Alaska pollack)	50.6
〃	53.1
〃	53.8
"Frozen Surimi" steamed for 10 min	76.3
〃	80.1

Before extraction, H_2O_2 was added to the weighed sample at a level 1 ppm.

while the sensitivity corresponds to 1/2 that of the original method, but is approximately 20 times higher than the modified colorimetric method[2] in the previous report. The calibration curve is produced on the day of measurement. (10)

Adding H_2O_2 to the weighed samples (amount equivalent to 1 ppm relative to the sample), the added H_2O_2 recovery rates in the entire analytical process from extraction to measurement have been shown in Table 1. With unheated samples the recovery rate was 51 - 84%, while with heated samples a value of 76 and 80%

was obtained. H_2O_2 is deemed to be an unstable compound so it may be unreasonable, but an improvement by a notch in the recovery rate would be desirable.

In the results of analysis of H_2O_2 by the original method and modified method, the original method in many cases indicated a lower value than the modified method (Table 2). With "Kazunoko," by the modified method admittedly low values in the 1/10 ppm level have been obtained as measured values, whereas by the original method no H_2O_2 has been detected. Because a neutral extractant which indicates a high catalase activity has been employed in the original method, when the sample is an unheated raw one, it is thought that catalase originating in the sample acts at the time of sample crushing or during preservation of the extract and it is feared an undermeasurement of H_2O_2 is obtained.

Table 2. Hydrogen peroxide values determined by the original and the modified methods.

Sample	H_2O_2 ppm	
	by the original method	by the modified method
"Kazunoko" (salted herring roe)	ND	0.12
〃	ND	0.37
〃	ND	0.14
"Kamaboko" (fish cake)	0.67	0.77
〃	0.79	0.56
〃	0.74	0.93

The original method: Sampls were extracted with neutral buffer solution, pH 7.0.
The modified method: Samples were extracted with acidic buffer solution, pH 2.7 (see also Fig. 3).

Results of H_2O_2 measurement in seafoods

H_2O_2 was measured by the modified method described above in fish roe foods such as "Kazunoko" and "Sujiko," foods such as fish paste products, "Shirasu," dried fish and shellfish products, and fish meal. A number of examples of the measured values have been presented in Table 3 - 6. Because the moisture content differs greatly depending on the food item tested, for comparative reference the moisture content has been shown alongside.

Table 3. Hydrogen peroxide contents in fish roe foods.

Sample	H_2O_2 ppm	Moisture %	Notes
"Kazunoko" (salted herring roe)	0.12	61.2	Not treated with H_2O_2
"	0.40	66.5	"
"	0.30	63.7	"
"	0.11	63.6	"
"	0.18	63.4	"
"Sujiko" (salted salmon roe)	0.54	46.9	Foods on the market
"Ikura" (salted salmon roe)	0.50	46.3	"
"Tarako" (salted roe of Alaska pollack)	0.18	60.5	"
"	0.38	55.3	"

In Table 3, salted "Kazunoko" (H_2O_2 untreated salted "Kazunoko") shows 0.1 - 0.4 ppm H_2O_2, while market-sold "Sujiko," "Ikura" (salmon roe), "Tarako" (cod roe) show similar values of 0.2 - 0.5 ppm.

In Table 4, H_2O_2 untreated fish paste products indicate values of 0.1 - 0.7 ppm, while market-sold fish paste products also show values of roughly the same level at 0.2 - 0.8 ppm. (11)

In Table 5, H_2O_2 untreated "Shirasu" (boiled) shows values of 0.2 - 0.9 ppm, while on the other hand market-sold "Shirasu" (boiled) and dried "Shirasu" indicate a wide range of values of 0.5 - 2.6 ppm, with well dried low moisture samples showing relatively high values.

The results of analysis for dried fish and shellfish products on the market and fish meal have been shown in Table 6. Because the dried products in many cases are usually served after cooking, the samples were heat-treated beforehand (99 - 100° C, ten minutes) and then extracted and the H_2O_2 measured. A wide range of values from under 1 ppm to 7.7 ppm was indicated, while the moisture content also revealed a large spread between 11 - 73% depending on the sample. With fish meal a high value in the several tens of ppm was even seen.

In Tables 3 - 6 the samples range in moisture content from under 10% to close to 80%, making an overall grasp of the H_2O_2 value unreasonable. For this reason, they were sorted into a number of groups in terms of the H_2O_2 value

converted to a dry basis, and the confidence intervals of the mean values were determined, the results of which have been graphed in Fig. 6. Because the number of samples analyzed was not many, the confidence intervals ended up being wide. With H_2O_2 untreated "Kazunoko," fish paste products, "Shirasu" and such, the H_2O_2 value on a dry basis was 0.5 - several ppm, so it would be appropriate to regard values of this level as being the background value for these foods. With dried fish and shellfish products on the market, the mean value of H_2O_2 on a dry basis was 4.9 ppm, indicating a value one notch higher than the foregoing food items. As one cause of this high value, as will be discussed later the effect of heat treatment of the sample and the effect of lipid oxides contained in the sample can be considered.

Table 4. Hydrogen peroxide contents in "Kamaboko" products.

Sample (processing)	H_2O_2 ppm	Moisture %	Notes
"Kamaboko" (steamed)	0.49	73.5	Processed without H_2O_2 treatment
"Chikuwa" (broiled)	0.60	73.5	〃
"Hampen" (boiled)	0.13	79.1	〃
"Satsuma-age" (fried)	0.72	72.5	〃
"Kamaboko" (broiled)	0.77	73.2	Foods on the market
〃 〃	0.42	76.3	〃
〃 (steamed)	0.33	77.8	〃
〃 〃	0.19	76.3	〃

Table 5. Hydrogen peroxide contents in "Shirasu" products.

Sample	H_2O_2 ppm	Moisture %	Notes
"Shirasu" (boiled whitebait)	0.19	68.1	Processed without H_2O_2 treatment
〃 〃	0.48	65.7	〃
〃 〃	0.59	76.4	〃
〃 〃	0.89	64.4	〃
"Shirasu" (boiled whitebait)	2.59	63.6	Foods on the market
〃 〃	0.46	65.0	〃
〃 (boiled-semidried product)	1.01	43.4	〃
〃 〃	1.24	37.6	〃
〃 (boiled-dried product)	2.41	15.5	〃

Table 6. Hydrogen peroxide contents in some dried marine foods* on the market and fish meal.

Sample	H_2O_2 ppm	Moisture %	Notes
"Maruboshi-iwashi" (dried-salted sardine)	4.45	45.2	Foods on the market
"Tatami-iwashi" (dried whitebait)	4.12	10.5	〃
"Tazukuri" (dried young sardine)	5.72	15.2	〃
"Niboshi" (boiled-dried sardine)	5.74	14.0	〃
"Hoshi-kibinago" (dried blue sprat)	7.72	29.3	〃
"Aji-hirakiboshi" (dried-salted horse mackerel)	0.46	72.6	〃
"Maruboshi-sanma" (dried-salted saury)	2.21	44.3	〃
"Migaki-nishin" (dried herring)	4.76	15.7	〃
"Tara-sukimi" (dried-salted cod fillet)	1.34	40.1	〃
"Saki-ika" (dried squid meat)	0.96	25.5	〃
"Hoshi-himegai" (boiled-dried round clam meat)	4.51	16.8	〃
"Hoshi-sakuraebi" (boiled-dried spotted shrimp)	1.31	17.8	〃
fish meal (sardine)	18.7	5.13	
〃 〃	34.9	4.06	
〃 (Alaska pollack)	2.8	7.21	

* Before extraction, the weighed samples were steamed for 10 min.

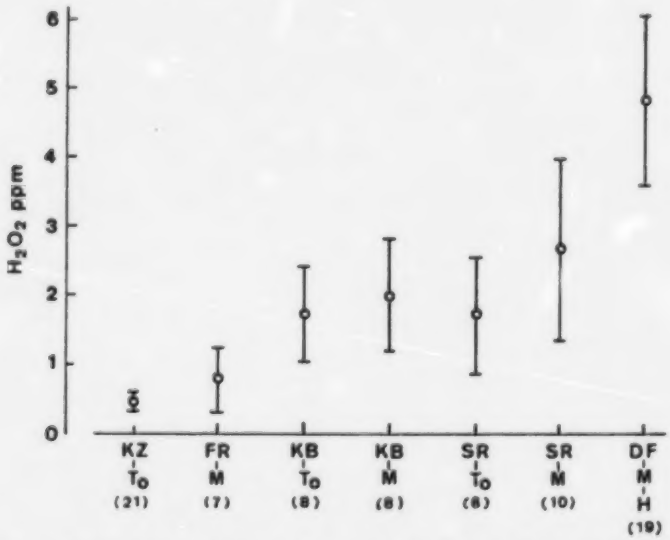

Fig. 6. Hydrogen peroxide contents in marine foods. Mean value and confidence interval (95 %) on dry basis.
KZ: "Kazunoko" (salted herring roe), FR: fish roe food products (salmon and Alaska pollack) KB: "Kamaboko" (fish cake), SR: "Shirasu" (boiled whitebait), DF: dried fish (see also Table 6), T_0: foods processed without H_2O_2 treatment, M: foods on the market, H: determination were made after heating of the weighed sample (see also Fig. 3) Figures in parentheses show number of samples analyzed.

Effect of heat treatment on H_2O_2 value (13)

With the fish paste products in Table 4, even the H_2O_2 untreated items indicated H_2O_2 values of 0.1 - 0.7 ppm and were not ND. In Fig. 6, compared to "Kazunoko," "Sujiko," "Tarako" and such raw samples, the fish paste products and "Shirasu" which are heat-treated in the manufacturing process can be seen to have a generally higher H_2O_2 value. For this reason, the effect that heat treatment has on the H_2O_2 value was investigated (Table 7). With "Surimi" for use in fish paste products the H_2O_2 is a low value, but became a high value with heat treatment and took on a value similar to fish paste products. Even with "Tarako" an increase in H_2O_2 value was discerned with heat treatment. When myosin B was prepared from white croaker muscle by the dilute precipitation method and this sol was heat-treated, an increase in the H_2O_2 value was discerned. In the case where solutions of chicken egg albumin (recombined five times) and bovine serum albumin Fr. V were

Table 7. Hydrogen peroxide contents in some marine foods and proteins before and after heating for 10 min (steaming).

Sample	H_2O_2 ppm		Notes
	before heating	after heating	(moisture %)
minced fish meat for "Kamaboko"	0.08	0.73	84.3
〃	ND	0.33	72.7
"Tarako" (salted roe of Alaska pollack, on the market)	0.38	0.81	55.3
〃	0.12	0.90	33.0
myosin B sol (white croaker muscle)	0.14	0.54	94.9
〃	0.18	0.62	89.4
egg albumin (chicken) solution	0.36	0.94	83.8
bovine serum albumin (Fr. V) solution	0.09	0.76	81.0

Table 8. Changes in peroxide value and hydrogen peroxide contents in methyl linoleate during storage at 30°C for 10 days.

Days stored	POV	H_2O_2 μg/g methyl linoleate
0	62	—
3	199	ND
6	622	ND
10	1879	17.5

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heat-treated as well, an increase in the H_2O_2 value was seen. The mechanism whereby the H_2O_2 value starts indicating a high value in refined protein itself due to heat treatment has not yet been investigated. The reason that the H_2O_2 value is low with unheated "Surimi" and "Tarako" is thought to be due to the action of catalase originating in raw samples, while the reason that the H_2O_2 value is high in fish paste products and "Shirasu" which have been heat-treated can be construed as being due to both a loss in catalase activity and the effect of heat treatment of protein itself, the mechanism of which is not clear.

With foods that are served after cooking like dried fish products, it is thought desirable to carry out the extraction and measurement of H_2O_2 after heat treatment. By following this method, it means the effect of heat treatment will be incurred and the H_2O_2 value will indicate a high value. This high value, however, is probably something that should be understood as being a H_2O_2 value that takes into account the actual cooking conditions.

Oxidation of lipid and H_2O_2

Using methyl linoleate (approximately 99% pure) as a sample, leaving it at 30° C and taking part of it every several days, solution A was added to this and well shaken, after which centrifugal separation (10,000 rpm, 25 minutes) was done and the resultant supernatant was taken as the lipid washing. This washing was handled in the same way as a sample extract and the H_2O_2 was measured (Table 8). In ten days at 30° C, an increase in POV and an increase in H_2O_2 were discerned. From this result, it can be understood that a value attributable to the oxidation (14) of lipid also gets included in the H_2O_2 measurement value by the oxygen electrode method.

With the modified H_2O_2 colorimetric method[2] in the previous report, H_2O_2 was reacted with 4-aminoantipyrine and phenol in the presence of peroxidase and the formed quinone imine compound (reddish pink colour) was colour-compared. In the same report, it was stated that when lipid extracted from "Kazunoko" was

used as a sample, the washing obtained from the said lipid left at room temperature indicated the same colouration as due to H_2O_2 and that the colouration value increased. This means that with both the colorimetric method and oxygen electrode method which differ in reaction principle, it shows that the oxidation of lipid increases H_2O_2. TOYODA et al.[4] have reported that, where methyl linoleate has been irradiated with ultraviolet rays and autoxidation has progressed, it contains H_2O_2, and that if the lipid peroxide fraction is shaken with water H_2O_2 readily forms.

In Fig. 6 it stands out that the H_2O_2 value of dried fish and shellfish products (extracted and measured after heat treatment) is higher than the value for fish paste products and "Shirasu." With these dried products, aside from the effect of heat treatment, it can be thought that a value attributable to the oxidation of lipid also gets included.

The source no doubt varies, but the fact is clear that the aforementioned seafoods do contain H_2O_2 albeit a trace. The author has experienced the fact that even in yogurt, coffee milk, frozen tofu as well as "Kamaboko" (fish cake), H_2O_2 can be similarly seen.* TOYODA[4] has stated that "Kazunoko," fish paste products, dried "Shirasu," processed cheese, yogurt and such contain traces of H_2O_2. A certain type of lactic acid bacterium is known to form H_2O_2.[10] A few years ago, the carcinogenicity of H_2O_2 was raised as an issue, and since then the use of H_2O_2 in foods has come under tight regulation practically equivalent to prohibition. Together with the quantification of H_2O_2 at the 1/100 ppm level (for solutions) having become possible by the development of analytical methods of high sensitivity, it has been made clear that various foods contain traces of H_2O_2 which can be deemed to be their natural content levels. From a food hygiene point of view, an investigation is earnestly desired of the question of the

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* Unpublished

carcinogenicity of H_2O_2 which takes into account even the H_2O_2 content around the level actually seen in foods.

Seafoods are often relished by garnishing them with gratings of "Wasabi" (a horseradish, Eutrema wasabi) and white radish. The effect of such "Wasabi" and white radish on the H_2O_2 of seafoods shall be reported on separately.

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